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River Crossings
What Have We Learned In 40 Years

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OVERVIEW

- **DESIGN**
- **CONSTRUCTION**
- **OPERATIONS**

THEMES

- **SO WHAT?**
  - Interesting? Does it matter?
- **WHAT IF?**
  - We will never know everything
  - Thus how do we ensure acceptable risks

DESIGN – STEPS

- **FLOW**
  - Water Level → Scour = Pipe Depth
- **SCOUR**
  - Bank Erosion → Floodplain Changes = Crossing Extent

FLOW – THEN

- **Limited/no data north of Brooks Range**
  - Used very conservative rainfall/runoff model
  - BUT, 1992 flood >> design flow

FLOW – NOW

- **35 – 40 years of data north of Brooks Range**
  - Adequate for flood frequency analysis
- **Unique conditions**
  - Influence of lakes/wetlands. “Release” of outlets in spring
  - Ice jam releases – up to 5X peak flow possible
  - Glacier dammed lake releases

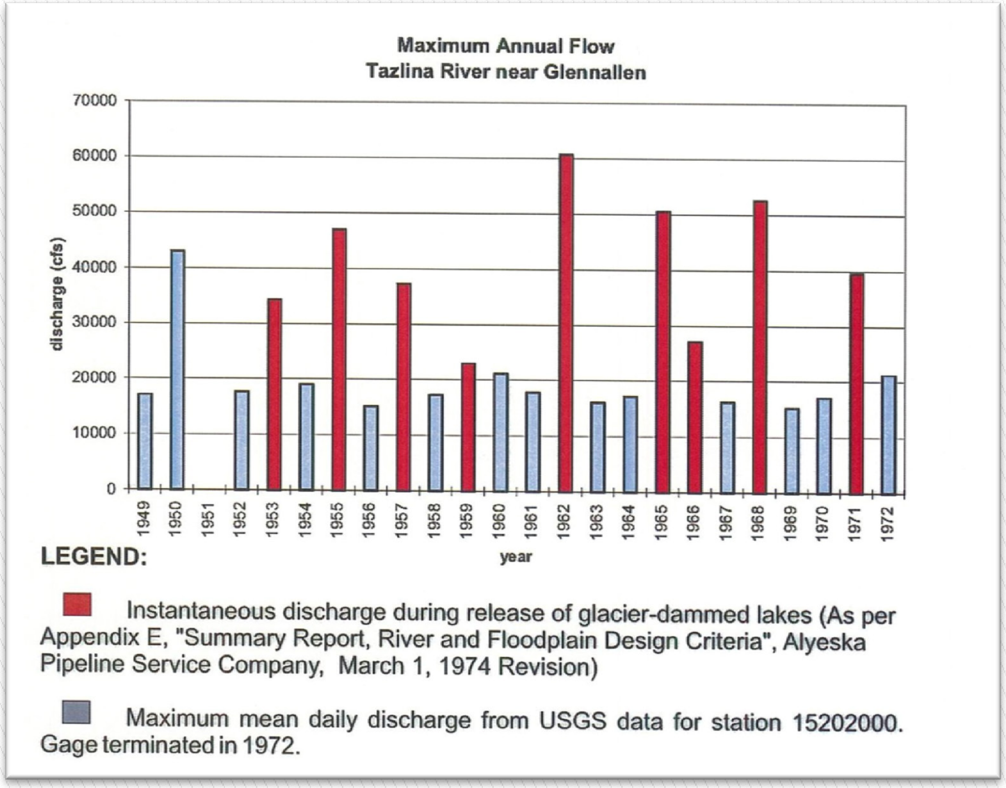
FLOW
GLACIER DAMMED LAKE RELEASES

- **History of releases? Flow data?**
- **Triggered by:**
  - Snow melt (typical)
  - And/or heavy rain (Tazlina R, 1997)
  - Neither – some mid-winter releases (Tazlina R, 2005)

Tazlina River

GLACIER DAMMED LAKE RELEASES

- **What if/Impact?**
  - Buried crossing
  - Elevated crossing
  - River training structures
  - 1997 Tazlina River Flood greater than design



WATER LEVELS

- **Summer floods**
  - Same as non-arctic rivers
- **Spring floods**
  - Flow over ground - fast icings
  - Ice jams/jam releases

AUFEIS (ICINGS) LEVELS

- **General theory =**
  - Cold + Low Snow = maximum icings

- **But site specifically, the opposite can occur**
  - 1975 Dietrich River, cold, low snow = maximum icing at MP197 = long dike required to protect TAPS
  - 1976 Dietrich River, warm, high snow = maximum icing one mile downstream = flooding of the Dietrich camp.

WATER LEVELS – WHAT IFS

- **Impact of aufeis (icing) levels on:**
  - Buried crossings – minimal
  - Elevated line/crossings – could be significant
  - River training structures – could be significant
- **Terraces can limit maximum icing levels**
- **Flow downcuts through icings or deteriorates the ice in 3-5 days.**

SCOUR – TYPES

- **General**
  - straight channel scour during floods
  - usually not significant if stream is in “regime”
- **Local scour**
  - At bends, confluences, debris jams and structures
  - 1.5 to 3.5 x general scour depth

SCOUR COMPUTATION

- **General Scour**
  - Regime
  - Competent Velocity
  - Mathematical Models
- **Local Scour**
  - Present and future channel conditions
  - Qualitative/empirical data
- **SO WHAT ?**
  - General scour not significant generally
  - Local scour much more significant
  - Is pipeline exposure = failure?

SCOUR – UNIQUE CONDITIONS

- **Spring**
  - Over ice/frozen ground
  - Minimal scour
- **Ice jams**
  - Severe scour at jam
  - Scour during jam release
- **Alluvial fans/debris flows**
  - Deposition
  - Channel changes
- **Mackenzie River Delta**
  - Hydraulic/thermal conditions

BANK EROSION/CHANNEL CHANGES

- **Summer Floods**
  - Same as non-arctic rivers
  - Survey historic erosion during major floods. Use this as a “trigger” to determine when bank protection is required for operating lines.
  - Bank erosion, especially in treed areas which generate debris, is a prime threat to buried pipelines
- **Spring Floods**
  - Frozen/snow covered banks = little bank erosion
  - Overflows in floodplains = little scour or channel changes in the floodplain. Structures can be affected.

BANK EROSION/CHANNEL CHANGES

- **Caused primarily by:**
  - High floods = sediment movement = debris = channel changes = bank erosion
  - All things being equal, less changes on Arctic rivers especially those north of the Brooks Range

DESIGN – RELATIVE IMPORTANCE BURIED CROSSINGS

	Low	Medium	High
Streamflow			
Peak	X →	X	
Low	X		
Water Level			
Open Water	X →	X	
Ice	X →	X	
Bed Scour			
General		X	X
Local		→	X
Bank Erosion			X

Quantitative vs. Qualitative Analysis

DESIGN – RELATIVE IMPORTANCE ELEVATED CROSSINGS

	Low	Medium	High
Streamflow			
Peak			X
Low	X	-	-
Water Level			
Open Water			X
Ice			X
Bed Scour			
General		X	
Local			X
Bank Erosion		X →	X

CONSTRUCTION

- **Various techniques for:**
  - Environmental reasons
  - Construction reasons
- **Arctic construction – hot oil pipelines**
  - A "dry" frozen ditch is not necessarily optimum
  - Impact of icings on feasible flow isolation methods

CONSTRUCTON TECHNIQUES

Frozen “dry” ditch

Open cut, wet ditch.

Flow Isolation- Pipe Flume

Flow Isolation-Pumping

OTHER CONSTRUCTION TECHNIQUES

Open Cut – Sauerman Dragline

HDD

Bore

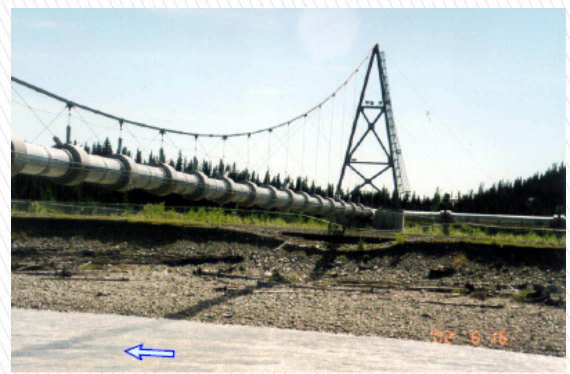
Flow Isolation - Superflumes

ELEVATED CROSSINGS

Free span of pipe

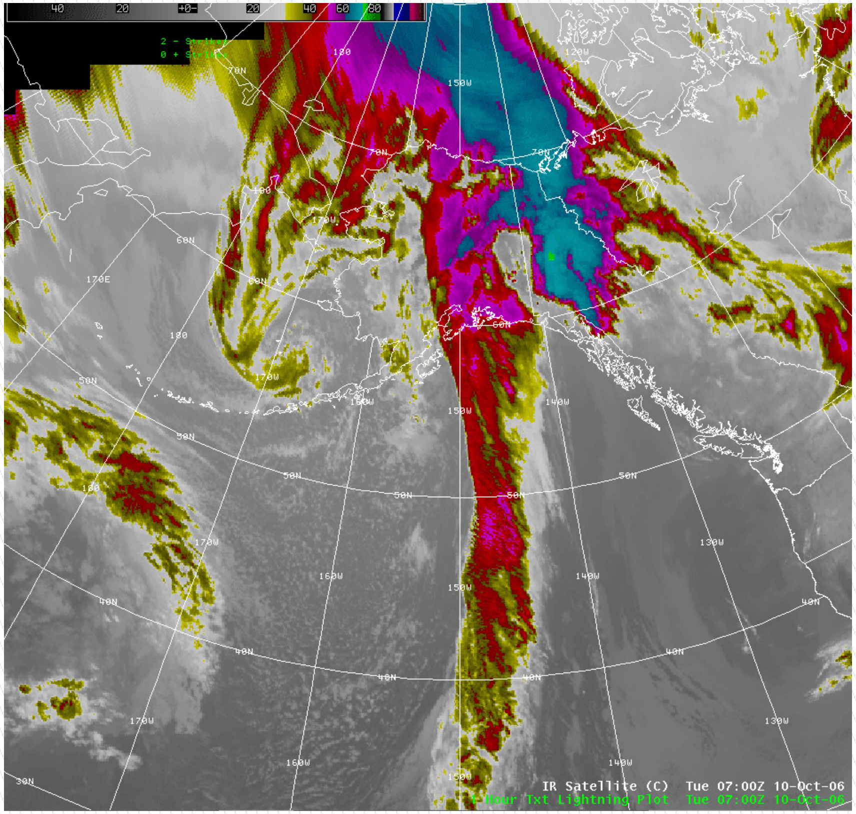

Pile Supports

Girder Bridge


Suspension Bridge

OPERATIONAL MONITORING

- **Extreme event - 2006**
- **Impact on:**
  - Access roads and highways
  - Buried pipeline
  - Elevated pipeline
- **Consequences of impact**
  - Access
  - Integrity
  - Rebuild or upgrade



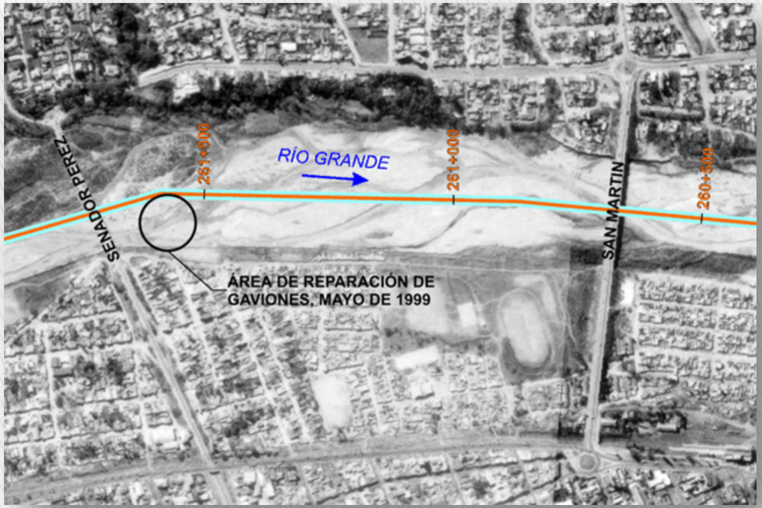
LESSON #1

Adapt to Conditions

LESSON #2

Schedule for Conditions

LESSON #3



Challenge Conventional Design Wisdom

LESSON #4

Challenge Conventional Regulatory Wisdom

"Do You Know What Tsina River Means"

LESSON # 5

Understand Scope of Commitment

LESSON #6

Utilize Operational Performance Data

LESSON #7

Value of Hands-On Knowledge

LESSON #8

Utilize Local Knowledge


THANK YOU